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Hydrogen Fuel Cell Technology in the National Park System

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Mr. Chairman and members of the subcommittee, thank you very much for the opportunity to contribute to this hearing today on the use of hydrogen as an energy source within the National Park System. My name is Mark Grisham. I am the executive director of the Grand Canyon River Outfitters Association, a trade association that represents each of the sixteen river-running concessioners licensed to operate in Grand Canyon National Park.

I have been asked to speak today about the potential for developing a hydrogen-based motorized pontoon boat suitable for recreational river running operations in Grand Canyon National Park. The purpose would be to capitalize on this emerging technology to continue to address concerns about motor noise and emissions along the Colorado River corridor within the Grand Canyon.

Over the past few years, the Grand Canyon River Outfitters Association has conducted research into the area of alternative motorized watercraft. We have built and gained experience with two electric motorboat test vehicles. Our view is that within a period of perhaps six to eight years, it will likely be possible to develop, construct, validate for safety and reliability purposes, and begin to implement silent, or nearly silent, zero emissions, or ultra low emissions, hydrogen-powered motorboats suitable for the conduct of professionally-outfitted recreational river trips within the Grand Canyon.

I would like to emphasize, however, that such an achievement would likely come about only as the result of a committed and sustained partnership between the river concessioners, the National Park Service, other elements of the federal government that possess relevant technical expertise (such as various offices or laboratories within the Department of Energy), and private sector entities that specialize in electric vehicle development and the use of hydrogen gas as a vehicle fuel. The active support of the conservation community would also be helpful.

There are also significant economic and policy questions that would need to be addressed successfully in order for a deployment of non-traditional motorboats to take place within the Grand Canyon.

Before going further, I would like to state that I am not a technical expert in these areas. I am not an engineer nor an electric vehicle specialist. The Grand Canyon River Outfitters Association has involved itself in these questions because we seek to respond to issues raised about our historic use of conventional outboard motors in the sensitive river corridor area of Grand Canyon National Park. The chief complaint is motor noise. To a lesser extent, motor emissions have also been raised as a concern. In addition, there are those who philosophically oppose any kind of mechanized use on the river, even that which would be virtually silent and emissions free.

Backing up a bit, I would like to explain briefly who we are and describe our community's mission, which in a nutshell is to make a high quality, educational Grand Canyon river experience available to the American and international publics. To do this,

we offer a diverse range of trip styles, of which the motorized options are far and away the most popular with those who actually purchase for themselves and go on professionally-outfitted Grand Canyon river trips. Today, three out of four of our passengers select a motorized trip for their experience.

Our patrons range in age from elementary school kids traveling with their parents to retirees in their seventies and eighties traveling with their children and grandchildren. The outdoor experience level varies from the highly proficient to those who have literally never spent a night camping out of doors prior to their river trip. This diversity of interest is one of the most powerful things about the Grand Canyon river experience. The significant majority of our patrons view a Grand Canyon river trip as a once in a lifetime experience.

We consider ourselves partners with the National Park Service, and a vital means by which the NPS mission is fully realized at the Grand Canyon. Working with the NPS, we provide the means for most who wish to experience and enjoy the Grand Canyon in an intimate way from the river to accomplish this goal. At the same time, we contribute to the area's protection and conservation, as the Grand Canyon is one of the most special, unique, and powerful natural wonders found anywhere on Earth.

I would like to emphasize that, to the best of our knowledge, there is no credible evidence suggesting negative resource or ecological impacts associated with the type and level of motorized use now occurring on the Colorado River within Grand Canyon National Park. The Grand Canyon motor debate involves visitor experience, aesthetic considerations, and philosophical matters, not resource protection imperatives.

Each year, we help roughly 19,000 people enjoy a professionally-outfitted Grand Canyon river trip. Of about 640 trips offered annually, about 480 are motorized, and 160 are non-motorized. Three out of four of all professionally-outfitted passengers currently depend on motorized rafts for the conduct of their trip. These rafts make possible a full canyon river trip in six to eight days. Without the motorized trip option, a full canyon trip would take roughly twice as long, about two weeks. Because many Americans simply do not enjoy that much vacation time, motor trips allow many thousands of Americans to experience the Grand Canyon by river who would otherwise not have the opportunity.

In 1997, the Grand Canyon's river concessioners voluntarily committed to a transition from the two-stroke outboard motors then in use, to thirty horsepower four-stroke models. After a $1.5 million capital investment program, we completed the transition from two-stroke to four-stoke for the start of the 2001 river season. The benefits provided by the four-stroke motors we now use are dramatic. These motors are substantially quieter than those they replaced. And there is an enormous reduction in emissions, including a ninety-five percent reduction of released hydrocarbons. These are the lowest impact, most environmentally friendly outboard motors available.

Encouraged by the success of our four-stroke conversion, we began to question whether or not we could capitalize on other emerging alternative vehicle technologies. To get some answers, we undertook a research project designed to examine the feasibility of engineering an electric motorboat that would be virtually silent and produce zero or ultra low emissions. We began talking to experts. We eventually built two electric motorboat test vehicles that we operated on area lakes, and eventually ran down the Colorado River. At the time, the National Park Service was strongly supportive of these efforts.

After completing this research, we have drawn a few preliminary conclusions. First and most importantly, we are convinced that, at low but still useful power levels, an electric motorboat operating in the soaking wet world of Grand Canyon river running is not such a crazy idea to contemplate, and that related safety issues can be successfully addressed.

The electric drive portion of the system is fairly straightforward. As with electric automobiles, the prime hurdles that remain derive from the question of how to either store or generate enough electricity onboard to give the vehicle sufficient range. In our case, the distance the boat must travel is fixed. A Grand Canyon motorboat needs to be self-sufficient and self-contained to the extent that it can travel reliably from Lees Ferry to Lake Mead. Anticipating what might happen in the next few years with the level of Lake Mead and the possible associated impact on equipment take-out locations, this is a distance of about 320 miles.

To overcome the range limitation problem just for testing purposes, we stocked our test bed vehicles with a substantial volume of sealed, gel-cell batteries, which addressed concerns about potential battery leaks resulting from an accident. These batteries were recharged while underway using a conventional gasoline-powered electricity generator mounted on the boat.

Our initial goal was to gain experience with the electric drive elements of the system. For this narrow purpose, replacing a gasoline-powered outboard motor with a gasoline-powered electricity generator made sense. But obviously, simply replacing one internal combustion engine operating on fossil fuels with another does not represent much of a change.

On a hydrogen-based boat, the gasoline-powered generator would need to be replaced with one fueled with hydrogen. There are two realistic options. The first is a fuel cell. Fuel cells contain no moving parts. They are quiet, and they produce zero pollution. Heat and water are the only byproducts. Fuel cells are, however, at this point in time at least, extremely expensive, as they are not yet readily available on the open market in a fully commercialized form.

In the alternative, electricity could be generated onboard by using a more traditional internal combustion power generator that burns hydrogen directly instead of gasoline or another fossil fuel. Such devices are currently available, and are not nearly as

expensive as fuel cells. It is likely that such an appliance could be effectively shielded against noise transmission, rendering them very quiet, if not essentially silent.

One final hydrogen-based option would be to scrap electricity entirely and modify a conventional four-stroke outboard motor to burn hydrogen gas directly. This can be done, but the likely problem would be that a hydrogen-fueled outboard would still make noise, probably in the order of what we already have.

In the hydrogen-based fuel cell option, the basic configuration of the system would be similar to our test vehicles. The fuel cell would generate electricity on an around the clock basis, providing a continual trickle recharge to the battery bank. An electric motor of suitable specification would be mounted in a conventional outboard motor housing, directly attached to the lower unit's drive shaft. The electric motor would draw electricity from the batteries as demanded to power the boat. The fuel cell would depend on hydrogen gas supplied from onboard tanks.

We have done no work to date on the related hydrogen fueling, refueling, storage, or supply issues and would need to depend on others with the requisite expertise for assistance in these areas. Designing a suitable hydrogen storage system is a significant undertaking, but we are given to understand that the engineering and fabrication presents no insurmountable technical hurdles. There are also more exotic forms of hydrogen gas storage under development around the world that may in the future prove promising, such as nickel-metal hydride storage.

As you can imagine, when we put it all together, what I am describing is a custom crafted, complex system, far more so than the conventional gasoline-powered outboards now in use. From a cost perspective, there is little doubt that such a system would be quite expensive. There is also the question of reliability and the related issue of redundancy. Again, a Grand Canyon river boat must be self-sufficient from launch to take-out. Cost considerations and physical space requirements would likely limit opportunities for parallel, redundant components in a fuel cell or hydrogen gas supply system. That means that the reliability of the core system must be very high, or back-up provided by some other means, such as a conventional four-stroke outboard.

Another approach that we feel also deserves close examination is to use a more conventional electricity generator powered by an internal combustion engine that runs on hydrogen gas instead of gasoline. A hydrogen-based generator would be fueled in a manner similar to a fuel cell, using onboard supply tanks. The generator in this configuration could either be set up to recharge a battery bank, or to power the electric outboard motor directly.

In this instance, we feel that noise issues could successfully be addressed through proper isolation mounting and shielding of the generator. For example, on our second electric test bed vehicle, on which we generated electricity with a small bio-diesel fueled generator designed for use on off-shore sailboats, the generator was so well shielded that

the only way those on the watercraft could tell it was running was by placing a hand on the boat's frame to feel for vibration.

Regardless of the pros and cons of these two different approaches, using hydrogen as a fuel means developing suitable supply, fueling, storage, and transportation equipment, procedures, and facilities. Hydrogen is, after all, a highly explosive gas whose treatment demands great respect. It is problematic in a sense because it is very light in weight. That means that either large volumes, great compression, or a combination of the two are needed to achieve the necessary storage volume, or energy density. Hydrogen can also be stored as a super-cooled liquid, but this introduces additional, and substantial, handling and safety issues of which we are quite wary.

As I stated at the outset, based on our research and discussions with experts in the field, we do believe that within perhaps a six to eight year timeframe, the development of a silent or nearly silent, zero or ultra low emissions alternative Grand Canyon motorboat will be technically feasible. This boat would likely be powered with an electric motor ultimately dependent on an onboard supply of hydrogen gas, in order to give the necessary range. In the context of hydrogen-based automobile development, advances are occurring regularly that will hopefully, in the foreseeable future, facilitate the extent to which a hydrogen-based Grand Canyon motorboat could be fabricated from proven, readily available, and cost effective components.

I wish to emphasize again that the success of any serious alternative Grand Canyon motorboat development project is dependent on the formation of a committed and sustained public/private partnership. Such a partnership must include the river concessioners, the National Park Service, other parts of the federal government such as various elements within the Department of Energy, and private sector alternative vehicle development experts or suppliers. The active support of the conservation community, which has been lacking to date, could also prove critical.

For our part, despite having substantial concerns about the many technical, safety, reliability, and economic questions that remain unanswered, the Grand Canyon River Outfitters Association and its member companies would look forward to participating in a serious partnership working in pursuit of a safe, reliable, essentially silent, zero or ultra low emissions hydrogen-based propulsion system suitable for recreational whitewater river-running operations within Grand Canyon National Park.

Thank you very much.

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